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Study on Grass Spider as a Predator to *Hyphantria cunea* DRURY

(Experiment on effectiveness as a predator of *Agelena opulenta* L. KOCH)

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I. Introduction

The writer learned from the basic study(1) of three years as from 1964 to 1966 that grass spiders effectively work on control of *Hyphantria cunea* DRURY.

In addition, in parallel with this basic study, the preliminary experiment(2) has been made on how much these grass spiders prey upon *Hyphantria cunea* DRURY and in this experiment the writer found that *Agelena opulenta* L. KOCH was better in the rates of prey and settlement than *Agelena limbata* THORELL. From April 1967 the experiment on effectiveness as a predator has been made by use of *Agelena opulenta* L. KOCH only. While the effectiveness has appeared slightly since then, in the fourth year, 1970, this grass spider as a predator has proved quite helpful and the writer has a confidence in practical application.

The writer now summarized the results of four years' experiments and publishes them for information for those interested in this problem.

In the performance of this study, the writer wishes to extend his thanks to Drs. Kyozo YASUMATSU, Toshio UEMURA and Takeo YAGINUMA who afforded various instructions and suggestions and meanwhile, the writer's appreciation should be given to Messrs. Seiji MATSUMOTO, Tetsuji OKOCHI, Eiichi SHINKAI, and Hirohisa KUNIMI of the Spiders Association and the members of the writer's family who cooperated in this study.

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(1) Acta Arachnologica VOL. XXI, No. 1, July 1, 1967.

(2) The educational research of the private school bulletin No. 16, March 25, 1969.

II. Method of Study

1. Period of study

It was from April 1967 to September 1970 that the experiment was actually made in the mulberry farm but the result of the study was summarized April 1971.

2. Establishment of mulberry farm for the study

a) Experimental plot:

The experimental plot for this study was the mulberry farm which is located to the west side of the plot used for the preliminary test. The area covers 480 square meter and 429 mulberry trees were planted.

b) Controlled plot:

The controlled plot for this study was the mulberry farm located to the north-east of the preliminary test plot. It is only 50 meter apart and the area was 460 square meter and 412 mulberry trees were planted. The distance between the experimental plot and controlled plot is 100 meter and two mulberry farm and three kitchen gardens were located between these two plots.

3. Preparation of mulberry farm for the study

In the experimental plot, at the beginning of every June, all grass spiders and other species of spiders in the plot were removed and 200 grass spiders prepared in advance were liberated.

In the controlled plot, at the beginning of every June, all grass spiders and other species of spiders were removed. Eventually, any species of spiders were not found in the farm. However, as the study in two plots went on since then, it was found that more or less spiders have made inroad into the farm from the outside.

In the experimental plot, even if 200 spiders were liberated, the number decreased to a half after one month and no remarkable change in the number was found and it seemed that they were settled there.

4. Method of study on the effectiveness as a predator

When this insect is in the stage of larva, it infests on mulberry trees. In Tokyo area, we have such infesting seasons from June to September in a year and during this study, we had three experiments every year. The first experiment is June-July and the second one July-August and the third one August-September. As a habit of this insect, at the early stage of larva, they produce threads each other and form one ball-like net in which they live in group and defoliate mulberry trees. This ball-like net is gradually expanded and becomes large but when the larva passes its early stage, in order to live independently they come out from the ball-like net and they break up and infest all over mulberry trees.

When the number of insects was checked, as it is difficult to know it after they break up, the number of group ball was counted when they live in group in the ball-like net and the number of insects was estimated. In this one group, 300 larvae were found on the average. In the result of the study, the one infestation means that this ball-like net is one.

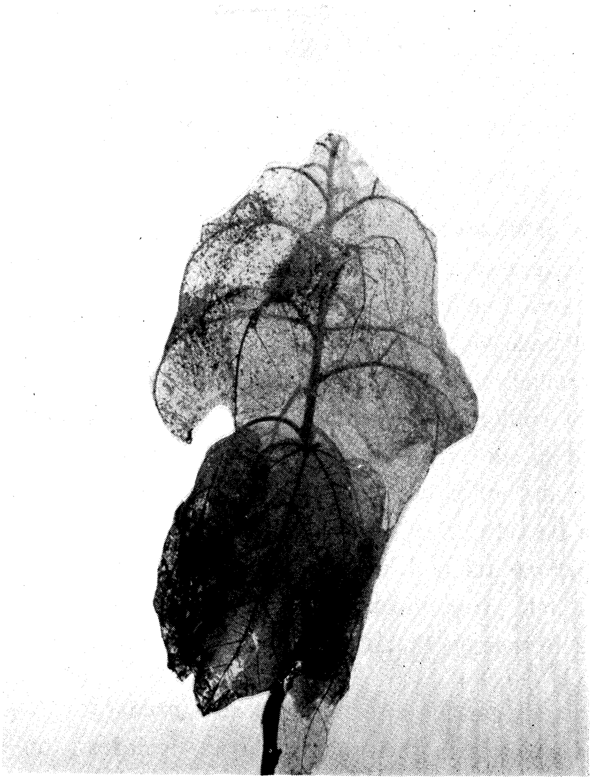

Fig. 1. Ball-like net which the early stage larva of *Hyphantria cunea* DRURY produces.

III. Results of Study

1. The number of *Agelena opulenta* L. KOCH living in the mulberry farm

i) First year (1967)

Experimental plot: When the number of grass spiders was counted on the daily mean of the first study (1st July-11th July) 65 spiders were nesting and living. Because 200 spiders were liberated in this mulberry farm on 1st June, it means that 32.5% of spiders settled. On the daily mean of the second study (10th August-17th August), 76 spiders, 38% were settled. On the daily mean of the third study (1st September-10th September), 73 spiders were living which means 36.5% of settlement.

Such low rate of settlement is considered to be due to two reason: the one is that several strong winds visited this region. Particularly, the strong wind visited in middle June was severe and mulberry trees fallen down. As a result, it seemed that grass spiders were blown to the near-by mulberry farms from the study farm. The other reason is that it was considered that 200 grass spiders were too many comparing with the area of the mulberry farm for study. It is a problem of place where spiders make nests and today, we have such a way of cultivation of mulberry trees that the stock is low, from which 5-10 slender branches grow and as a result, the mulberry trees themselves are not so large. Under such conditions, it seems that 200 grass spiders could not find any place to nest.

Controlled plot: In this plot, before starting the experiment, grass spiders were removed and not a spider was found there. However, since then some spiders might have made inroad and when the survey was made on the daily mean of the first study (1st July-11th July), the writer found that 8 spiders were nesting. On the daily mean of the second study (10th August-17th August), 6 spiders and on the daily mean of the third study (1st September-10th September), 11 spiders were found. It is considered inevitable to see that such number of spiders came in from the outside.

ii) Second year (1968)

Experimental plot: On the daily mean of the first study (1st July-9th July), 104 spiders, 52% were considered to be settled. On the daily mean of the second study (9th August-14th August), 108 spiders, 54% and on the daily mean of the third study (31th August-8th September) 96 spiders, 48% were settled. After all, during the days of this study, 51.3% of spiders were settled on the average.

Controlled plot: on the daily mean of the first study (1st July-9th July), 16 spiders, on the daily mean of the second study (9th August-14th August), 13 spiders and on the daily mean of the third study (31th August-8th September), 21 grass spiders were found in the plot.

iii) Third year (1969)

Experimental plot: On the daily mean of the first study (1st July-10th July), 84 spiders, 42% were settled on the daily mean of the second study (10th August-15th August), 111 spiders, 55.5% and on the daily mean of the third study (1st September-9th September), 102 spiders, 51% were found. On the daily mean of this study, 49.5% of these spiders on the average were settled. This shows the rise of rate of settlement by 14.5% comparing with the year before last and the reduction by 1.1% comparing with the previous year.

Controlled plot: On the daily mean of the first study (1st July-10th July), 19 spiders, on the daily mean of the second study (10th August-15th August), 14 spiders and on the daily mean of the third study (1st September-9th September), 16 grass spiders were found in the control plot and this was almost the same with the previous year.

iv) Fourth year (1970)

Experimental plot: On the daily mean of the first study (26th June-5th July) there were 107 spiders, 53.5%, on the daily mean of the second study (20th July-30th July) 101 spiders, 50.5% and on the daily mean of the third study (19th August-26th August) 113 spiders 56.5% were settled which was the increase of 4%, comparing with the previous year.

Controlled plot: On the daily mean of the first study (26th June-5th July) 11 spiders, on the last day of the second study (20th July-30th July), 14 spiders, on the daily mean of the third study (19th August-26th August), 8 grass spiders were found in the controlled plot. This condition was almost the same with the previous year (Table II). From the above four years' study, the writer concluded that when 200 grass spiders were liberated every year in the experimental plot, a half of them escaped to the outside of the plot.

However, because those once escaped often stay nearby or return to the original plot, there had been some change in the number of spiders whenever the study was made. Those settled often change the position of nest but they seem not to be away from the plot. Actually in the mulberry farm

Table I. Number of living grass spiders in mulberry farm (daily mean)

Year	No. of Experiment	Period of Experiment	Experiment Section	Control Section
1967	I	1st July —11th July	65	8
	II	10th Aug.—17th Aug.	76	6
	III	1st Sept.—10th Sept.	73	11
1968	I	1st July — 9th July	104	16
	II	9th Aug.—14th Aug.	108	13
	III	31th Aug.— 8th Sept.	96	21
1969	I	1st July —10th July	84	19
	II	10th Aug.—15th Aug.	111	14
	III	1st Sept.— 9th Sept.	102	16
1970	I	26th June— 5th July	107	11
	II	2nd Aug.—10th Aug.	101	14
	III	26th Sept.— 2nd Sept.	113	8

which is being used, when the manager walked around in the farm without paying any attention to nests, the rate of settlement reduced to a great extent. Even if 200 spiders were liberated, as more or less 100 spiders escaped, it seemed reasonal to liberate 100 spiders from the beginning but when 100 spiders were liberated from the start, they were not broken up in all the farm but tended to live close together partially and the number of spiders to settle decreased more and more. Eventually, it seems that when the experiment begins every year, 200 spiders are necessarily to be liberated.

2. Infestation of *Hyphantria cunea* DRURY in the experimental and controlled plots.

i) First year (1967)

Experimental plot: During the first study (1st July-11th July), the group of *Hyphantria cunea* DRURY which infested on mulberry trees in the plot was counted 43, mostly on mulberry trees on the borders and some of them were broken out in 4 groups on one tree. In the second study (10th August-17th

August), 25 groups in total were broken out and most of them were found on the border. In the third study (1st September-10th September), 19 groups were found on the border too. After all, in the experimental plot of the first year, 87 groups of this insect in total were broken out.

Controlled plot: During the period of the first study (1st July-11th July), 55 groups were broken out and in the second study (10th August-17th August), 46 groups were broken out and infested on mulberry trees adjacent to previously damaged trees. In the third study (1st September-10th September), 28 groups were broken out on the west border. After all, in the comparison plot of the first year, 129 groups of insects were broken out. Many mulberry trees which entirely lost leave were found.

ii) Second year (1968)

Experimental plot: In the year of the first study (1st July-10th July), the outbreak of the insect was so early that their groups were formed late June. On 9th June, group season ended. In this season 22 groups were found. Outbreaks were mostly found on the border. In the second study (9th August-14th August), 18 groups, and the third study (31th August-8th September), 8 groups were found and the number of groups were reduced in the first, second and third in order. In the second year, 48 groups of insects were broken out and comparing with the first year, the number was reduced by 39 groups.

Controlled plot: In the first study (1st July-9th July), 47 groups were broken out and mostly found on the border. In the second study (9th August-14th August), 51 groups were broken out on the west border. In the third study (31th August-8th September), 33 groups were broken out on the border too. Through the period of study, 131 groups were broken out and comparing with 129 groups of the previous year, the number of groups was increased by 2 in the controlled plot.

iii) Third year (1969)

Experimental plot: In the first study (1st July-10th July), 11 groups were broken out on the circumference regions. In the second study (10th August-15th August), 7 groups were broken out. In the third study (1st September-9th September), 4 groups were broken out. The outbreaks of the current year were 22 groups and comparing with that of the year before last, 65 groups and comparing with that of the previous year 26 groups were reduced respectively.

Controlled plot: In the first study (1st July-10th July), 27 groups, in the second study (10th August-15th August), 20 groups and in the third study (1st September-9th September), 29 groups were broken out. During the current year, 76 groups were broken out. When the outbreak of infestation of the current year of the comparison plot was compared with those of the year before last and the previous year, we outbreaks in the current year.

iv) Fourth year (1970)

Experimental plot: In the first study (26th June-5th July), as the outbreak of the insect was so early that the study started as early as 26th June. Till the last day of this study, 13 groups were broken out. In the second study (20th July-30th July), 10 groups were broken out on the border too. In the third study (19th August-26th August), 3 groups of insects were found. The number of outbreaks in the current year was 31 groups which was reduced by 15 groups comparing with that of the previous year.

Controlled plot: In the first study (26th June-5th July), 36 groups were broken out which was 9 groups more than that of the same season of the

Table II. Number of damages by fall-web worms in mulberry farm (actual number)

Year	Period of Experiment	Experiment Section	Control Section
1967	1st July —11th July	43	55
	10th Aug.—17th Aug.	25	46
	1st Sept.—10th Sept.	19	28
1968	1st July — 9th July	22	47
	9th Aug.—14th Aug.	18	51
	31th Aug.— 8th Sept.	8	33
1969	1st July —10th July	11	27
	10th Aug.—15th Aug.	7	20
	1st Sept.— 9th Sept.	4	29
1970	26th June— 5th July	13	36
	2nd Aug.—10th Aug.	10	34
	26th Aug.— 2nd Sept.	8	21

previous year and the year was that of too many outbreaks. In the second study (20th July-30th July), 34 groups were broken out which was 14 groups more than that of the same season of the previous year and in third study (19th August-26th August), 21 groups were broken out and the total of the current year was 91 groups. It was not a great outbreak which was expected at first.

IV. Observation Concerning the Effectiveness of Grass Spider as a Predator to *Hyphantria cunea* DRURY

Based on the study described so far, when we consider how the grass spider acted as a predator in the control of *Hyphantria cunea* DRTRY, we may say as follows. In the first year (1967), 214 grass spiders were found in the experiment plot and noxious insects were broken out in 87 groups. In the controlled plot, 25 grass spiders were found and noxious insects were broken out in 129 groups. The experimental plot was less 42 groups in the outbreak of insects than the controlled plot. This may be due to the fact that in the experimental plot grass spiders were found 180 more than in the controlled plot.

Because 300 larvae on the average were found in on group of noxious insect $300 \times 42 = 12600$ of larvae were controlled by 189 grass spiders. This means that one grass spiders preys on 66.6 larvae of noxious insects. When the observation was made at each outbreak season of larva, at the first outbreak, 43 groups were found in the experimental plot. The infestation was spread all over the farm. When more than 30 groups are broken out in one season, its damage may spread over the farm and the condition is considered as a large damage. However when the group is counted 20-30, its damage will not spread over the farm and the extent of damage will be medium. When the groups are less than 20, the damage is partially and the extent of damage will be the least. Thus, when the group of larva in the experimental plot where grass spiders are liberated, is less than 20, the result is credited to this spider. It can not be considered that the predator only can entirely control noxious insects, and we do not expect it. If we control the outbreak of noxious insect effectively, the role of the predator is accomplished. At the second outbreak, 25 groups were found in the experimental plot which was less than 30 groups, and the damage is medium. In the comparison plot at that time, 46 groups were broken out and the damage was spread over the farm and the infestation was severe. At the third outbreak, in the experimentalled plot 19 groups were found and the damage was partially but in the controlled plot, 30 groups were found and the infestation was spread over the farm and the damage was serious.

In the second year (1968), in the experimental plot, 308 grass spiders were found and the number of noxious insects was 48 in group. In the control, 50 grass spiders were found and the infestation of the insect was 131 groups. As a result, in the experimental plot, more 258 grass spiders were living comparing with the controlled plot. This means the decrease of outbreak of noxious insects of 83 groups and 24900 larvae were controlled. In other words, one grass spider preyed upon 96.5 larvae. If we consider it from the viewpoint of extent of damage, except that at the first outbreak in the experimental plot, the number of groups was 22 and the damage was 22 and the damage was medium, the damages of the second and the third, the damage was partially and slight. In contrast, in the controlled plot, the outbreak of noxious insect was over 30 in group and the damage was severe. When the number of outbread of noxious insects in the experimental plot was compared with that of the year before last, it was decreased by 39 in group.

In the third year (1969), in the experimental plot, 292 grass spiders were found and groups of noxious insects were 46. In the controlled plot, 39 grass spiders were found and 76 groups of insects were broken out. In the number of spiders, in the experimental plot, it was 260 spiders more and in the outbreak noxious insects, it was decreased by 30 groups. In other words, 9000 larvae were controlled and one spider preyed on 34.7 larvae. Comparing with the previous year, the number of prey per one spider was decreased by 24.6. Because in this year, the owner of the farm came to the farm to harvest leaves of mulberry trees several times and destructed nests of spiders or removed the ball-like nests, the condition was somewhat changed comparing with the usual year. Considering the extent of damage of this year, in the experimental plot, the number of group of outbreak of noxious insect was less than 20 groups in the first, second and third seasons of outbreak respectively and the damage was locally and slight.

In the fourth year (1970), in the experimental plot, 321 spiders in total were found and the insects were broken out 31 in group. In the controlled plot, 33 grass spiders were found and the insects were broken out 91 in group.

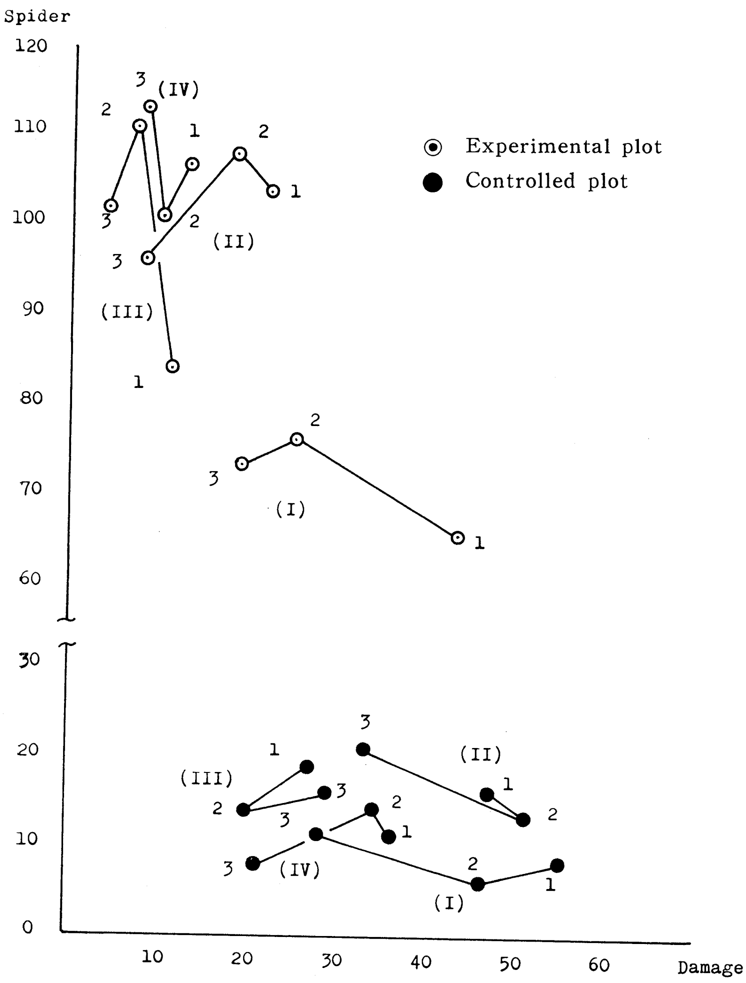

Fig. 2. Related graph of number of living grass spiders in mulberry farm to damages by fall-web worms.

This means that in the experimental plot, the spiders were 288 more and 60 groups less in the number of outbreaks. Then, the number of prey per one grass spider is 62.5 insects. Comparing with the previous year, more 27.8 insects were controlled. In the extent of damage, in the experimental plot, the number of group of outbreak was more or less 10 and the damage was locally and slight. However, in the controlled plot, the number of group was 30 on the average and infestation was spread over the farm (Fig. 2).

Summary

1) Grass spiders generally prey upon larvae of *Hyphantria cunea* DRURY. When these larvae shift from aggregation to the independent life, many larvae shift in high speed on thin branches and some on them lose footing and fall down like rain fall. These larvae fall on sheet like nests of grass spiders and spiders prey upon them. The shifting of these larvae is performed in the night.

2) Where *Hyphantria cunea* DRURY is distributed, grass spiders are also distributed.

3) Since the individual of grass spiders is too many, it is possible to collect its required number for affected mulberry farm in a short period of time.

4) Although the breeding of grass spiders is possible, it is hard to reproduce many at the present stage.

5) Grass spider does not harm on the growth of mulberry trees.

6) In the chemical spray, grass spiders escape quickly to the tunnel made at the end of sheet like net so that few of them are killed.

7) Because in the mulberry farm the number of grass spiders is not enough to control *Hyphantria cunea* DRURY in natural condition, we should liberate grass spiders each time.

8) When grass spiders are used as a predator for *Hyphantria cunea* DRURY we can not control entirely but we can reduce the damage slightly.

9) When we liberate a reasonable number of grass spiders in the mulberry farm every year, we can get a successful result as reported in this paper.

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